Probability of Detection and Multi-Sensor Persistence of Methane Emissions from Coincident Airborne and Satellite Observations

Ayasse, Alana, et al. (2024). Environmental Science & Technology (2024): 58 (49), 21536-21544. DOI: 10.1021/acs.est.4c06702

Science Questions

- Probability of Detection (POD) is an information content metric useful for understanding detection limits of individual (i.e., facility-scale) emission sources.
- POD also helps integrate data from multiple different instruments as detections vs. non-detections can be incorporated probabilistically at the facility scale
- What is EMIT's 90% probability of detection for individual methane emissions (i.e., super-emitting point sources)?

Analysis

- EMIT and GAO data were collected simultaneously over a high methane emitting region (Permian Basin) allowing for a direct comparison of plumes from the two instruments, POD analysis, and validation of a new persistence algorithm involving multiple instruments.
- Probability of detection is a function of the emission rate and the wind speed (among other things). Using the combination of positive detection and missed detection from the GAO/EMIT data we tuned an EMIT specific POD model that can now be leveraged to understand scene by scene POD and EMIT's general ability to observe methane plumes.
- We used EMIT's POD model to show how multiple instruments with different PODs can be combined into a cohesive framework, using Bayesian inference, to better estimate the persistence of an individual methane emission event.

Results/Significance

- EMIT has a 1000 kg/hr 90% POD at 3 m/s, using matched-filter retrievals.
- We introduced a new algorithm to estimate the persistence of an individual methane event. This new algorithm uses multiple instruments, which increases the volume of data that can be used in analysis. We also show how this leads to a more accurate estimation of emission persistence for a single source.

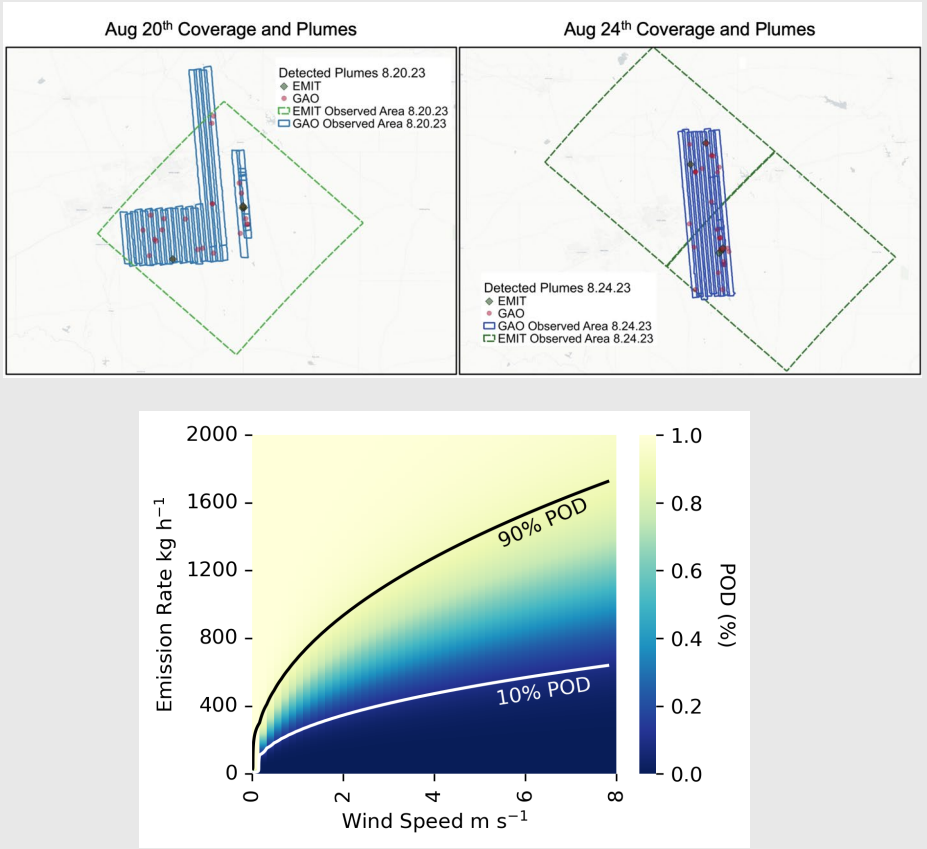

Figure 1: (Top panels) – joint observation in the Permian Basin with EMIT and Global Airborne Observatory (GAO). (Bottom panel) *POD heat map for EMIT. The 90% POD and 10% POD line are displayed for reference on the figure. The 90% POD at 3 m/s wind speed is 1000 kg/hr.*

Acknowledgements

This research was supported by the NASA Carbon Monitoring System (NNH22ZDA001N-CMS) under NASA Award Number 80NSSC23K1244 (Cusworth-CMS-2022).